Precision Measurement of μp Capture in Hydrogen

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The goal of this experiment is to improve considerably the present knowledge of the rate for the basic electro-weak capture reaction of a negative muon on a free proton, $\mu p_{1s} \rightarrow n + \nu_\mu$. The proposed measurement to 1% precision will provide stringent tests of theroretical predictions based on Standard Model symmetries and the chiral perturbation theory of QCD. In particular the capture rate is sensitive to the pseudoscalar form-factor g_p, the least well known among the nucleon charged-current form-factors. The present status of the theory requires measurements of g_p on the few percent level, while the precision of available experiments is worse by more than an order of magnitude.

The capture rate will be determinded by measuring the lifetime of μ^- stopped in ultra-pure, deuterium-depleted hydrogen at 10 bar pressure with a precision of 10ppm and comparing it to the lifetime of the free μ^+. The gas is contained in a pure hydrogen TPC acting as an active target and allowing us to insure that the muons stop in hydrogen and not wall materials.

In last year's report we described our success with a prototype TPC using natural hydrogen. This year we have designed the TPC for the final experiment which must be made of clean enough materials not to contaminate 1ppm deuterium-depleted hydrogen which has only 10ppb of other impurities.

The TPC is surrounded by two layers of MWPC's and a hodoscope to accurately track and time the decay electrons, see figure 1. The TPC is constructed only of materials which passed rigorous outgassing checks in a high vacuum test chamber and which are bakeable, see figure 2. The entire TPC and pressure vessel will be baked out under vacuum prior to introducing the valuable, clean, depleted hydrogen.

Simply vertex matching the decay electron track to the muon track reduces accidental backgrounds to less than 10^{-5}. Vertex matching also allows tracking several muons at once in the TPC and therefore the higher data rates necessary to collect 10^{10} statistics.

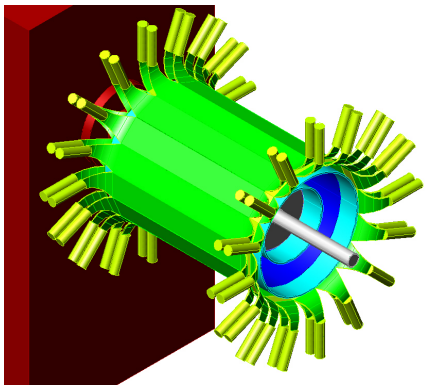

Figure 1: "MuCAP" setup: A TPC surrounded by 2 layers of MWPC's and a hodoscope.

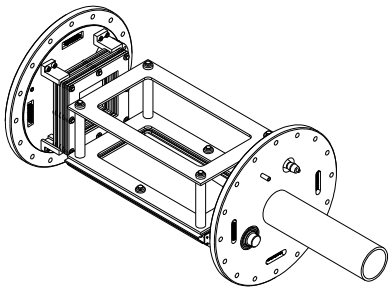

Figure 2: Bakeable TPC of quartz and ceramic for ultra-clean hydrogen. Muons enter from left.

The TPC signals are also used to make in situ measurements of residual impurities at the level of 1ppm for deuterium and 10ppb for the typical impurities: O_2, N_2 and H_2O.

Footnotes and References

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